AUSTRALIAN JOURNAL OF ENGINEERING AND TECHNOLOGY RESEARCH (AJMFR)
Vol. 2, Issue 1 - 2017

COMBUSTION ANALYSIS OF COAL USING COAL WATER SLURRY TECHNIQUE

Javaid Iqbal
Mechanical Engineering Department, Balochistan University of Engineering and Technology, Pakistan

Liaquat Ali Lehri
Mechanical Engineering Department, Balochistan University of Engineering and Technology, Pakistan

S. Mushtaq Shah
Mechanical Engineering Department, Balochistan University of Engineering and Technology, Pakistan

Mohammed Nadeem
Mechanical Engineering Department, Balochistan University of Engineering and Technology, Pakistan

Note: This paper has been accepted for publication from the submissions made at the 2nd National Conference on *Intelligent Manufacturing & Sustainable Energy Systems (IMSES 2016) - Pakistan*

Abstract

Geographically, Baluchistan is largest province of Pakistan and contain numerous energy resources, including natural gas and coal. This work focuses on the coal resources of Baluchistan considering their quantity and importance in the overall potential energy portfolio of the country. The available coal can be used by different methods, and the slurry technique is one of them. The energy crises create serious problems for development and growth of any country so to fulfill energy requirements of growing population, to overcome this problem and also for the environmental effects of the coal the coal water slurry is best technique of combustion. Coal water slurry is best alternative and creates 78% less pollution than other methods, and referred as clean coal technology. The experimental investigation using coal-water slurry technique for different coal Particle size has been compared and presented here in this research work.

Keywords: Coal, Combustion, Slurry, Environment, Investigation, size

1. WORLD ENERGY RESOURCES AND IMPACT ON THE ENVIRONMENT

The living standard of people of a country depends on basic needs like water, electricity and energy resources. Today the world energy demands are met by using fossil fuels and renewable energy resources. The energy resources can be visualized in terms of various parameters. The world population during current century may increase between 6 and 11 billion and the energy demand has been increased 35 times during last two centuries. [1] The main drivers of the alternative energy search are the population growth, economy, technology, and agriculture. The potential of renewable energy source is enormous as they can meet the world's energy demand. Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services

based on the use of routinely available, indigenous resources. Renewable energy sources currently supply somewhere between 15% and 20% of world's total energy demand. [2] Non-renewable energy resources are the conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging the environment.

2. PRIMARY AND SECONDARY ENERGY

The primary energy is new energy entering the system, and the energy that is transformed within the system is called secondary. [2] The Primary energy is used to designate those sources that only involve in extraction or capture with or without separation from contiguous material, cleaning or grading, before the energy embodied in that source can be converted into heat or mechanical work. [2]

3. NON-RENEWABLE ENERGY RESOURCES

A non-renewable resource is a natural resource that cannot be re-made or re-grown at a scale comparable to its consumption. Most of our energies come from non-renewable energy sources such as Coal, petroleum, natural gas, propane, and uranium are non-renewable energy sources. They are used to make electricity, to heat our homes, to move our cars, and to manufacture all kinds of products. There are many sources of energy in our world. We can get energy from the sun, from wind, and from falling water. We can also get energy from materials that contain stored energy. We call these materials "fuels." One of our most important sources of non-renewable energy today is fossil fuels. Fossil fuels take a long time to form. If we go back in geological history, we find that it took millions of years for our fossil fuels to come to be. Because of the time needed to form these fuels, and because the conditions for formation must be just right, most geologists feel that little or no new fossil fuel is being produced. For this reason, we call fossil fuels "non-renewable." They were formed between 50 million and 350 million years ago. The processes by which they formed are not totally understood. Decayed remains of ancient plants and/or animals were buried by sediments. Through the action of heat and pressure over millions of centuries, they were chemically changed. Coal, oil, and natural gas are the results [3]. Coal was formed from the remains of ferns, trees, and grasses that grew in great swamps 345 million years ago. These remains formed layers as they sank under the water of the swamps. The plant material partially decayed as these layers formed beds of peat, a soft brown substance that is up to 30% carbon. Peat is the earliest stage of coal formation. Shallow seas later covered the swamps and slowly deposited layers of sand and mud over the peat. These sediments exerted pressure on the peat over thousands of years. Slowly chemical changes took place transforming it to lignite or brown coal.

4. COAL

Coal is a non-renewable energy source. The energy in coal comes from plants that lived hundreds of years ago under the swamps. [3] Coal is one of the energy source that can be used in solid, liquid or gaseous form depending on the situation demands. Coal is the most abundant fossil fuel available worldwide. The global distribution of coal is non-uniform like any other mineral deposits or for that matter petroleum. For instance, one-half of the world’s known reserves of coal are in the United States of America. The primary use for coal is in the generation of electrical power. In Missouri State, more than 85% of generation is done by coal-fired power plants. Pakistan is a coal-rich country, but,

unfortunately, use of coal has not been developed for power due to lack of modern techniques expertise in power plant technology and coal mining. Other than this the financial problem was the main problem. Pakistan is fourth coal richest country of the world and has coal field in almost all provinces such as Harnai coal, mach coal, and Dukki coal in Balochistan has not been used for this purpose.

5. ENVIRONMENTAL IMPACT OF NON- RENEWABLE ENERGY RESOURCES

During combustion process, the fossil fuels release carbon dioxide, carbon monoxide, SOx and NOx. This results in the environment damage, and global warming. The emission of greenhouse gases is main factor for global warming, Carbon dioxide is one of those gases and has major role in global warming. Energy demand is increasing throughout the world and in order to get more energy, the more power plants need to be built. As it is known that thermal power plants burn different fuels like gas, oil, and coal called fossil fuels release different greenhouse gases as flue gas. In future, the rapid increase in demand will cause limitations in availability of fossil fuels, the resources available may decay. This increase in demand and flue gases emission will also have a major impact on the environment. Carbon dioxide is the main culprit for global warming; all fossil fuels on burning release carbon dioxide. Carbon dioxide emissions can be reduced by different techniques like adding biomass with fossil fuels and others. The coal water slurry technique is one of them.

6. BALOCHISTAN COALRESOURCES

Following coal, coal mining areas are active in Baluchistan

- Dukki,
- Khost
- Sharig
- Harnai
- Sor Range
- Degari
- Pir Ismail
- Ziyarat
- Mach
- Kingri

Producing about 50% of the coal production in Pakistan. The total coal reserves are about 217 million tons, of which 32 million tons are considered mineable. The thickness of coal seams ranges from 0.3 to 2.3 meters. Baluchistan coal is classified as sub-bituminous to bituminous and the heating value ranges from 9,637 to 15,499 Btu/lb. It has low ash and high sulfur coal and is considered suitable for power generation by co-firing with biomass because high sulfur may produce pollution [3]. Small power plants up to 25 MW can be set up in each coal field.

6.1. MACH COAL

Mach coal field lies in topo sheet No. 34 O/5 within a few kilometres radius of Mach railway station Bolan and Kalat Districts, having about 50 sq. km. of presently known coalfield area. The station is

situated 65 km from Quetta of Sibi-Quetta railroad which passes through the historic Bolan Pass. Coal in Mach area has been known since pre-partition times. Several coal seams are present in ranging in thickness from 0.3 m – 1.5 m but only 3 beds with an average thickness of 0.75m are commercially workable. The quality of coal is sub bituminous. The coal can be subjected to spontaneous combustion and is suitable for power generation of 21 to 24 MW. [3]

6.2. KHOST, SHAHRAG AND HARNAI COAL

Khost, Sharag and Harnai coal fields cover an area of 200 sq. km in the Sibi the District of Baluchistan. It is located at a distance of 160 km to the East and North East of Quetta. The Sibi-Khost extension of Pakistan railway runs along the coal fields. The coalfields are also connected by an unmetalled road. The coal is of Bituminous to Sub-bituminous quality. Coal beds are generally thin, and dipping at 60 degrees. The coal is considered suitable for power generation. Small power plants up to 50 MW can be set up, based on coal produced from these three small coalfields. [4]

6.3. SOR RANGE AND DEGARI COAL

The Sor-Range and Degari coal-fields are located about 12 km South of Quetta city, and extend southeast for a distance of 26 km, covering an area of about 50 sq. km. The northern half of the field is known as Sor-Range and the southern as Degari. Quetta is the nearest railhead for the Sor-Range mines and Spezand railway station for the Degari mines. There are the largest coal-producing fields Of Baluchistan. The coal field is approachable by a metaled road which encircles the entire coalfield joining the Quetta-Sibi highway near Spezand. The coal-bearing area is a doubly plunging symmetrical syncline. The coal seems generally dipped at angles of 45 to 50 degrees. The coal field lies in an arid to semi-arid region with an extreme temperature changes. It experiences that heavy snowfall and rain during winter, but little rain during summer. The thickness of the coal bed ranges from 0.3 m to 1.3 m. The total coal reserves are estimated about 50 million tons. The coal is sub-bituminous in quality and is considered suitable for power generation. Small power plants up to 25 MW can be set up in each Sor-Range and Degari coalfield.

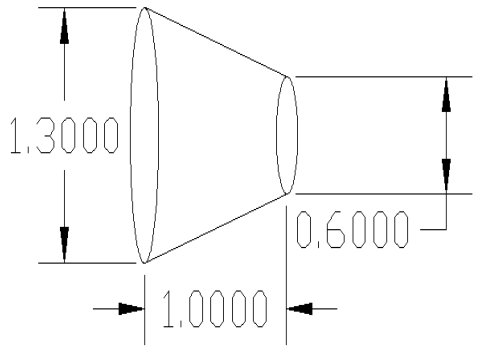
7. COAL WATER SLURRY FUEL (CWSF)

Coal-water slurry fuel is a combustible mixture of fine coal particles suspended in water. It can be used to power the boilers, gas turbines, diesel engines and heating and power stations. CWSF has inherent advantages over solid coal. It may be stored by different methods like in tanks. It can also be transported by a variety of methods like pipelines it can also be pumped or atomized. It can be burnt like a heavy fuel oil [5]. There is no dust explosion hazards and less space than pulverized or solid coal. Unlike pulverized coal, there is no need for expensive drying of the cleaned coal [5]. Recently, limestone has been added to slurries to capture sulphur oxides during the combustion process and reduce emissions [4]. Due to the high moisture content of CWSF, flame temperatures are considerably lower than in pulverized coal flames. This results in lower nitrogen oxide emissions [5]. However, since coals usually contain more fuel nitrogen than fuel oils, CWSF's nitrogen oxide emissions are correspondingly higher (report) than for fuel oil [5].

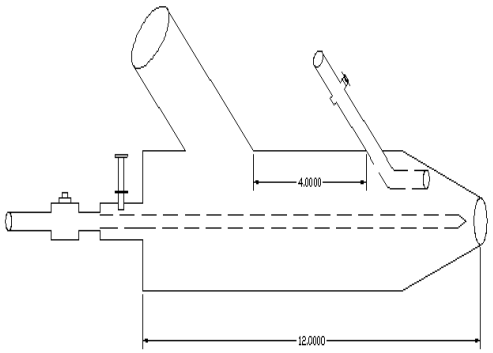
7.1. OBJECTIVE AND BURNER DESIGN

The objective of this research study is combustion analysis of coal available in Baluchistan, using CWSF technique with different coal particle sizes. The dimensions of nozzle are under:

- Length of Nozzle = 1 inch
- Internal diameter = 1.3 inches
- Outlet diameter = 0.6 inch



(a)



(b)

Fig. 2. Pulverized coal Burner

Fig. 3. Various size of sieves

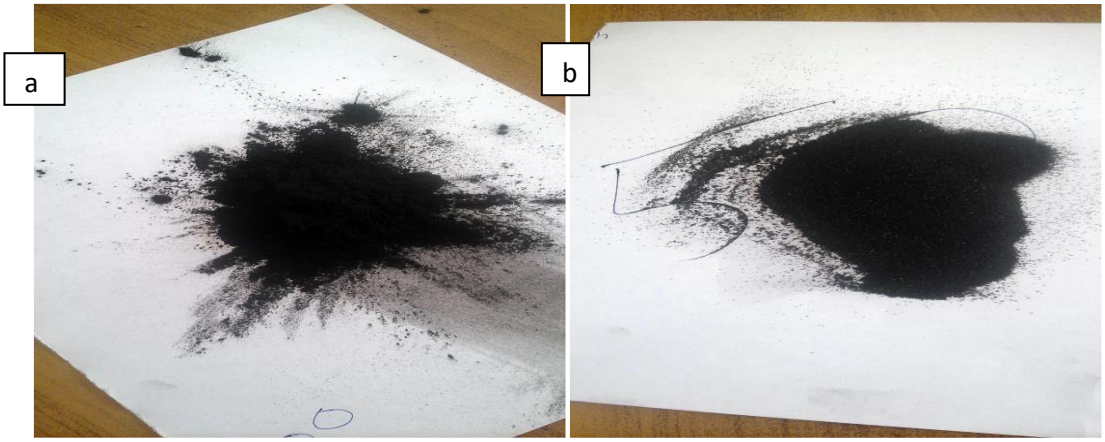


Fig. 4. (a) 200 micron coal particle size **(b)** 50 micron coal particle

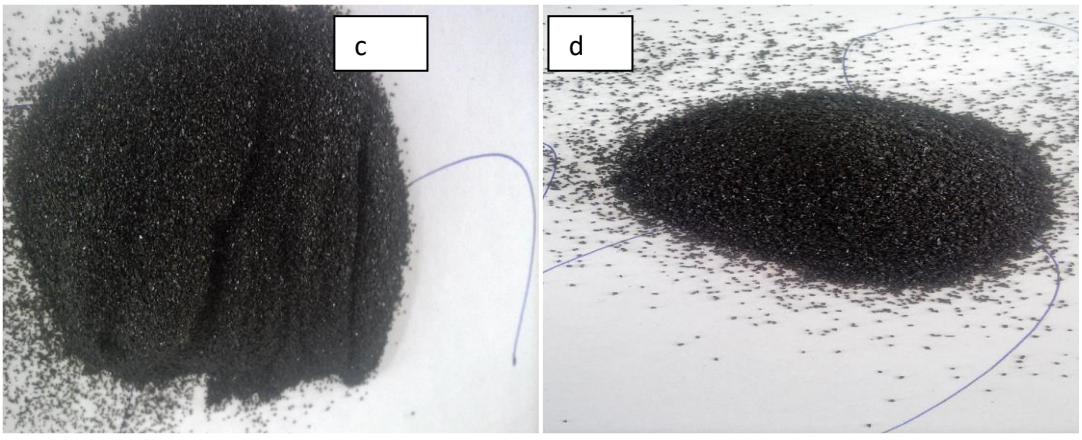


Fig 4. (c) 40 micron coal particle size **(d)** 30 micron coal particle size

7.2. PRODUCTION METHOD

The coal is grinded and mixed with water, then milled in microns using a roller mill (the mass media diameter or "mind" is typically 30 to 50 microns) and beneficiated to remove ash. After being dewatered, flow and stability improvers like grinded lime stone are added to yield the final product (report). Dispersants (surfactants, such as calcium lignosul phonate) help to wet and separate

individual coal particles and reduce the slurry viscosity, while stabilizers prevent the particles from settling into a hard-packed bed by suspending them in a weak gel. Stabilizers are generally starches, gums, salts, or clays (report). Other additives include freezing point depressants, biocides, and caustics (to control the pH of the product).

8. EXPERIMENTAL WORK

Sample of sub-bituminous coal was taken from the Sor Range of Baluchistan mines. Collected different particles size coal; for measurement, the several types of sieves with their respective numbers were used in the laboratory.

8.1. RESULTS

Adding 70% coal and 30% water; adding some other chemical additive such as wasted moble-oil, kerosene-oil, etc increases the efficiency of fuel [4]. For sustainable suspension of particles in water it is also essential that the mixture may be continuously agitated and in present study, it was agitated at 7000 to 9000 rpm. Particles size which were used are as under:

- 30 Microns particle size.
- 40 Microns particle size.
- 50 Microns particle size.
- 100 Microns particle size.
- 200 Microns particle size

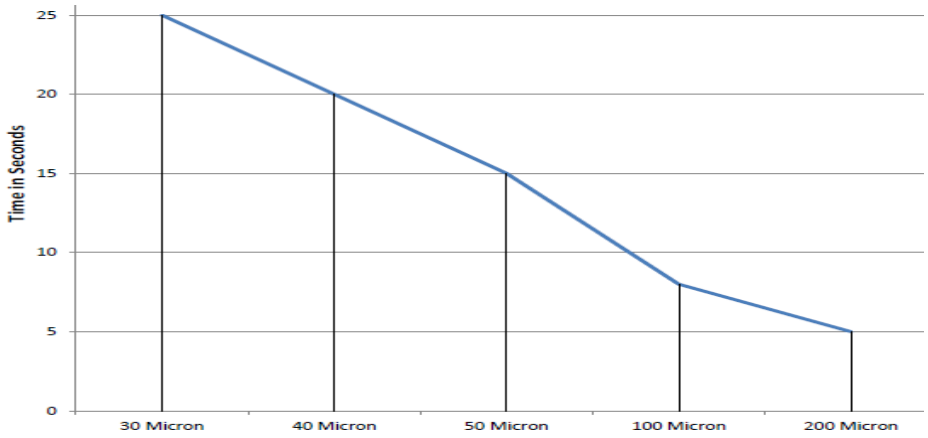
Table 1. Combustion behavior of CSWF at different water and coal ratios

Coal ratio	Water ratio	Combustion Behavior
50	50	Not sustainable
60	40	Not sustainable
70	30	Sustainable
80	20	Fluctuating

Table 2. Combustion behavior of CSWF at different water and coal ratio

Coal Size	Weight (Gram)	Combustion
200 Micron	60	Not Stable
100 Micron	60	Not stable
50 Micron	60	Stable
40 Micron	60	Stable
30 Micron	60	Stable

Figure 5. Stability time of different particle sizes



Particle Size

9. DISCISSION ANDCONCLUSIONS

Basically, the research is on bituminous coal available in Baluchistan Pakistan using coal-water slurry technique because the coal water slurry fuel has many advantages than the solid fuel. It can also be transported in easy way like pumping, pipelines and can easily be stored. This technique reduces the greenhouse gases releasing from the solid coal. So, the experimental work was done on different particle sizes of coal like 200,100,50,40 and 30 Micron. Also, the different water ratio and coal ratio was used to test. The results are given in the table 1, table 2 and Figure 5.

We can accordingly draw following conclusions:

- 30 Micron particle size of coal can be successfully combusted using technique
- 40 Micron particle size of coal can be successfully combusted using coal-water slurry technique.
- 50 Micron Particle size of coal can be successfully combusted using coal-water slurry technique.
- 30:70 coal water ratios could be used for sustainable combustion.
- The Baluchistan coal is best for power plants using coal-water slurry technique.

ACKNOWLEDGEMENT

The efforts taken by the author would not have been possible without the kind support of co-authors, Baluchistan University of Engineering & technology, Khuzdar, Pakistan Lab/workshop staff of BUETK, and Mines and minerals department, government of Baluchistan, Pakistan who provided us the services to do this research work. Authors would like to extend our thanks to all of them.

References

[1] Department of Economic and Social Affairs. (2004). *World Population To 2300.* United Nations, Department of Economic and Social Affair. Newyork: United Nations.

[2] A.K. Akella, R.P. Saini, M.P. Sharma., "Social, economical and environmental impacts of renewable energy systems" Renewable Energy 34, PP390–396, 2009

[3] Aroussi, A., and Iqbal, J., "Solid Fuel Biomass cofiring with coal", 4th International symposium on hydrocarbon and chemistry,pp.2-10, Ghardaia, March 24-26,2008.

[4] Overgaard, S., "Definition of primary and secondary energy", Standard International Energy Classification (SIEC), pp. 1-7, 1999

[5] Abeba, A., "Investment Opportunity in Coal of Ethiopia", Geological Survey of Ethiopia (GSE), pp. 1-40,2009

[6] Michael, D. "Impact of Energy Development on the Environment", report, University of Alaska, National Geographic, 2013

[7] Prakash, Ramachandran., Ching.Yi., Tsai and Gary. W.,Schanche., "An Evaluation of Coal Water Slurry Fuel Burners and Technology". ,USACERL TECHNICAL REPORT,coal Use Technologies,US Army Construction Engineering Research Laboratories, 1992